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SOLAR/1024-79/01

Monthly Performance Report

LIVING SYSTEMS

JANUARY 1979

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U.S. DEPOSITORY

U.S. Department of Energy

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

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MONTHLY PERFORMANCE REPORT

LIVING SYSTEMS

JANUARY 1979

I. SYSTEM DESCRIPTION

The Living Systems site is a single-family residence in Davis, California. The home has approximately 1700 square feet of conditioned space. The solar energy system consists of two independently controlled systems: an active system for preheating domestic-hot-water (DHW) and a passive system for space heating the home.

The active solar DHW system has an array of flat-plate collectors with a gross area of 46 square feet. The array faces south at an angle of 45 degrees to the horizontal. Potable city water is the transfer medium used throughout the system. In the event of freezing and no insolation, the controller drains the water from the collectors. When water in the collector is sufficiently warmer than the water in the preheat storage tank, the controller starts the circulation between the preheat tank and the collector. The preheat tank holds 82 gallons of water which is supplied, on demand, to a conventional 20-gallon DHW tank. When the water preheated by solar energy is not hot enough to satisfy the hot water load, a natural gas burner in the DHW tank provides auxiliary energy for water heating. The system is shown schematically in Figure 1.

The passive solar space heating system is of the direct-gain type illustrated schematically in Figure 2. Incident solar energy is admitted to the building through both the large south-facing vertical windows (approximately 200 square feet) and the overhead skylight (approximately 80 square feet at 60 degrees from the horizontal). Manually operated insulating curtains provide insulation during the night and sunless days for the south-facing collector windows. Manually operated insulating shutters also provide night insulation for the skylight glazing and are aluminum coated to provide reflection to the space below when open. Solar energy storage is provided by steel tubes that contain approximately 3600 gallons of water. The tubes are painted blue and placed near the south window wall and under the skylight. Additional storage is provided by the 6-inch-thick concrete slab floor of the building which is covered by ceramic brown tiles. Collected solar energy is distributed by natural convection, by conduction through the slab floor, and by radiation. Floor covering is minimal: linoleum in the kitchen and eating area and white shag rugs in two bedrooms. The building envelope is well insulated in order to ensure energy conservation, with R-19 insulation in the walls and R-30 insulation in the roof. The effective R-values of the windows are in the range of R-2 to R-10 (uncovered and covered with curtains and shutters). All glass surfaces are double-glazed with minimum window area in nonsouth-facing walls. Auxiliary space heating is provided by a gas-fired wall furnace which distributes the energy by natural convection. Additional auxiliary energy can be supplied from a wood-burning stove.

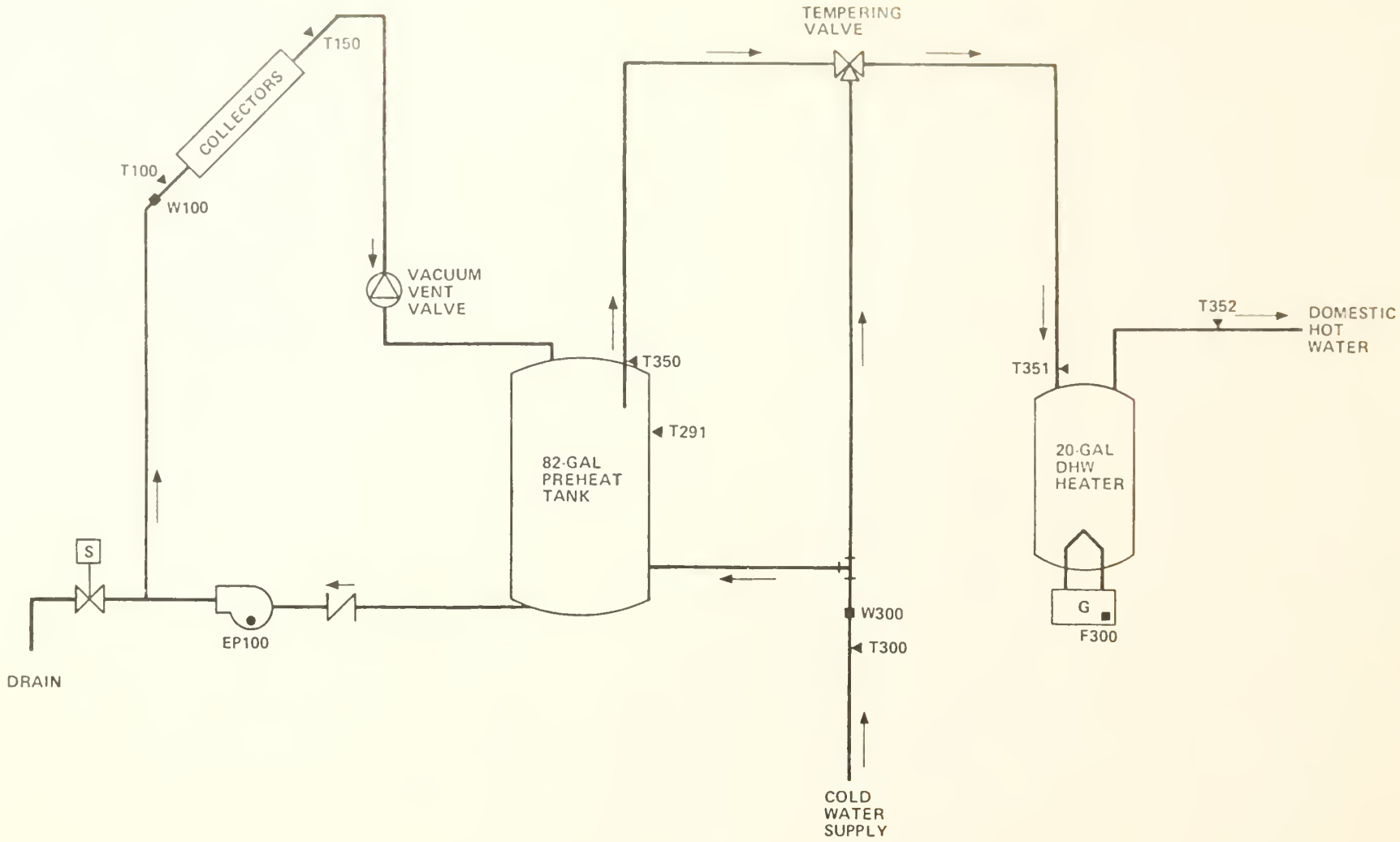

Figure 1. LIVING SYSTEMS ACTIVE SOLAR DOMESTIC HOT WATER SYSTEM SCHEMATIC

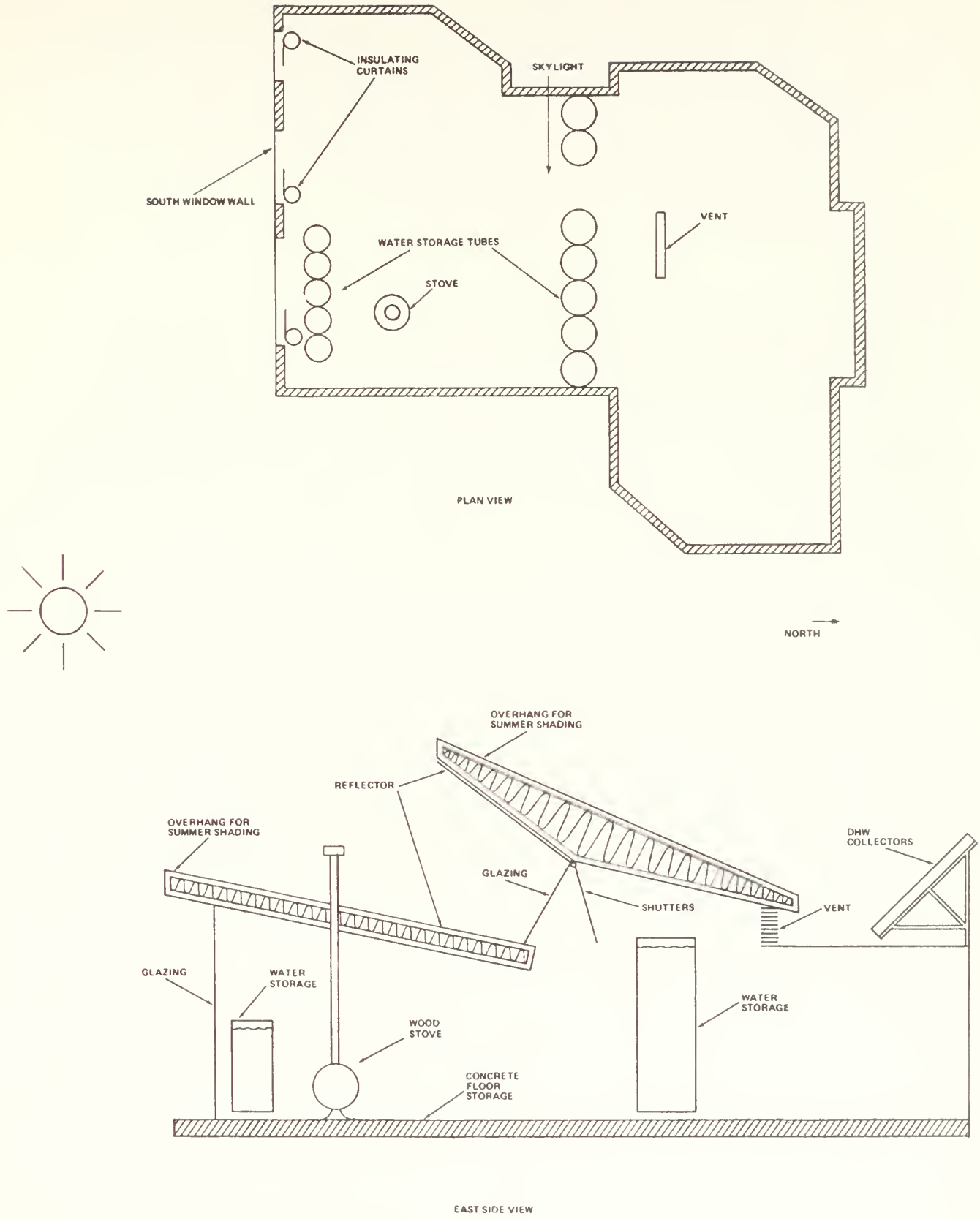

Figure 2. LIVING SYSTEMS PASSIVE SPACE HEATING SYSTEM

The building has summer overheat protection which is provided by several means: Roof overhangs over the south-facing glazed areas provide shading; operable windows in the south wall and a vent in the north wall provide cross-ventilation of the house at night, cooling the solar storage mass and moderating daytime building temperatures; the curtains and shutters over the windows prevent collection of incident solar energy during the day; and a ceiling fan assists the heat distribution and the venting process.

II. PERFORMANCE EVALUATION

INTRODUCTION

Performance evaluation is presented in two parts for this solar energy site: The first part covers the active solar DHW system; the second covers the passive solar space heating system.

The active solar DHW system was extensively damaged by freezing on December 8 and only limited information is available on this system. Spill-over from the passive system during the month of January satisfied 13 percent of the DHW load, while the passive solar space heating system satisfied 85 percent of the space heating demand during the month. Operation of the wood-burning stove during periods of low incident solar energy provided backup energy while reducing the space heating demand. Daily variations in building temperature were minimal, indicating the presence of substantial amounts of energy storage capacity. Comfort levels remained reasonable throughout the month.

WEATHER CONDITIONS, ACTIVE SOLAR DHW SYSTEM

During the month total incident solar energy on the DHW collector array was 1.2 million Btu for a daily average of 821 Btu per square foot. This was below the estimated average daily solar radiation for this geographical area during January of 995 Btu per square foot for a south-facing plane with a tilt of 45 degrees to the horizontal. The average ambient temperature during January was 44°F as compared with the long-term average for January of 45°F. The number of heating degree-days for the month (based on a 65°F reference) was 601, as compared with the long-term average of 617.

THERMAL PERFORMANCE, ACTIVE SOLAR DHW SYSTEM

Collector - The total incident solar radiation on the DHW collector array for the month of January was 1.2 million Btu. The collector system was inoperative due to freeze damage in December; however, while the collectors were inoperative, storage, pipes, sensors, etc. were still working. There was leakage of 0.078 million Btu from the passive space heating system into the DHW preheat system, resulting in an effective collector array efficiency of 7 percent, based on total incident insolation. There was no operating energy required by the inoperative collector loop.

DHW Load - The DHW system consumed 0.078 million Btu of solar energy and a measured 1.8 million Btu of auxiliary thermal energy (equivalent to 3.0 million Btu of auxiliary fossil fuel energy) to satisfy the hot water load of 1.9 million Btu. The solar fraction of this load was 13 percent. Losses from the DHW system were 0.031 million Btu. The passive system spill-over resulted in fossil fuel energy savings of 0.13 million Btu. A daily average of 124 gallons of DHW was consumed at an average temperature of 120°F delivered from the tank.

WEATHER CONDITIONS, PASSIVE SOLAR SPACE HEATING SYSTEM

During the month, total incident solar energy on the passive collector south windows and skylight was 7.1 million Btu for a daily average of 842 Btu per square foot. This was below the estimated average daily solar radiation for this geographical area during January of 1027 Btu per square foot for a south-facing plane with a tilt of 60 degrees to the horizontal. The average ambient temperature during January was 44°F as compared with the long-term average for January of 45°F. The number of heating degree-days for the month (based on a 65°F reference) was 601, as compared with the long-term average of 617.

THERMAL PERFORMANCE, PASSIVE SOLAR SPACE HEATING SYSTEM

The total incident solar radiation on the collector windows for the month of January was 7.1 million Btu. The total collected solar energy for the month of January was 4.8 million Btu. In January, the total solar energy delivered to the space heating load was 5.0 million Btu, resulting in a collector array efficiency of 70 percent, based on total incident insolation. Auxiliary thermal energy of 0.87 million Btu was added to satisfy a space heating load of 5.9 million Btu. (This was equivalent to 2.1 million Btu of auxiliary fossil fuel energy, which includes the pilot losses not applied to the load.) The result was a fossil fuel energy savings of 8.3 million Btu. The solar fraction of this load was 85 percent. The average storage temperature for the month was 69°F.

On many days during January, the wood-burning stove was used to satisfy a measurable amount of the building load. The thermal energy derived from operation of the wood-burning stove was applied as a reduction to the building load; that is, the major difference between the building load and the space heating demand was the energy derived from operating the wood stove. During January, this renewable energy was approximately 2.0 million Btu. Assuming a wood-stove energy conversion efficiency of 30 percent, this 2.0 million Btu is approximately equivalent to 22 percent of a cord of dry hardwood (such as oak). In terms of the savings of nonrenewable energy, the renewable thermal energy derived from the wood was equivalent to over 3.3 million Btu of fossil fuel energy.

The interior comfort level was given as 69°F in zone 1, the south end of the building, and 66°F in zone 2, the north end. The temperature difference

occurs because comfort zone 2 is heated by conduction through the slab floor and the walls, and by convection and infiltration through the doors. The cooler temperatures in the bedrooms are not objectionable to the occupants.

OBSERVATIONS

January was the first month in which the passive space heating system began working well. The new home owners used the insulating shutters and curtains in harmony with the weather over 90 percent of the time; any discrepancies are at least partially attributed to the weather forecasts. The insulative shutters, one of the back doors, and the insulative curtains were not fully operational.

In January, computed comfort levels inside the building were reasonable in both zones of the building. Zone 1 is the primary collection and storage area of the house. The comfort level in zone 2 was slightly lower than that of zone 1, due to the method of transferring heat to zone 2. Average daily variation in building temperature was only 2°F for the month. The maximum variation was 8°F, and centered on 63°F on January 16 and 62°F on January 26.

Because of freeze damage in December, the collectors were inoperative and considerable spill-over of solar energy ocurred from the passive system.

ENERGY SAVINGS

The solar energy system provided a total fossil fuel energy savings of 8.5 million Btu. Although the DHW system was inoperative, it received an energy boost from the passive system for a fossil fuel energy savings of 0.13 million Btu. The space heating system contributed an energy savings of 8.3 million Btu.

III. ACTION STATUS

The active DHW system was inoperative and required major repair by the owner; insulative shutters and curtains require work by the grantee or owner. IBM will replace the microboard associated with a wood-burning stove sensor that was installed by Boeing during the month.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: LIVING SYSTEMS (159-1) DAVIS, CALIFORNIA SOLAR/1046-79/01
REPORT PERIOD: JANUARY,1979

SITE/SYSTEM DESCRIPTION:
THE LIVING SYSTEMS SOLAR DOMESTIC HOT WATER SYSTEM PROVIDES PREHEAT TO THE BUILDING DOMESTIC HOT WATER SYSTEM . THIS ACTIVE SYSTEM USES FLAT PLATE COLLECTORS (46 SQ.FT.) TO HEAT WATER DIRECTLY IN A 82 GALLON STORAGE TANK. AUXILIARY HOT WATER ENERGY IS PROVIDED BY NATURAL GAS IN THE 20 GALLON HOT WATER HEATER.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	1.171	MILLION BTU
	25461	BTU/SQ.FT.
COLLECTED SOLAR ENERGY	0.000	MILLION BTU
	0	BTU/SQ.FT.
AVERAGE AMBIENT TEMPERATURE	44	DEGREES F
AVERAGE BUILDING TEMPERATURE	63	DEGREES F
ECSS SOLAR CONVERSION EFFICIENCY	0.07	
ECSS OPERATING ENERGY	0.000	MILLION BTU
TOTAL SYSTEM OPERATING ENERGY	0.000	MILLION BTU
TOTAL ENERGY CONSUMED	2.987	MILLION BTU

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	1.834	N.A.	N.A.	1.834 MILLION BTU
SOLAR FRACTION	13	N.A.	N.A.	13 PERCENT
SOLAR ENERGY USED	0.078	N.A.	N.A.	0.078 MILLION BTU
OPERATING ENERGY	N.A.	N.A.	N.A.	0.000 MILLION BTU
AUX. THERMAL ENERGY	1.787	N.A.	N.A.	1.787 MILLION BTU
AUX. ELECTRIC FUEL	N.A.	N.A.	N.A.	N.A. MILLION BTU
AUX. FOSSIL FUEL	2.978	N.A.	N.A.	2.978 MILLION BTU
ELECTRICAL SAVINGS	N.A.	N.A.	N.A.	0.000 MILLION BTU
FOSSIL SAVINGS	0.129	N.A.	N.A.	0.129 MILLION BTU

SYSTEM PERFORMANCE FACTOR: 0.616

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978, SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: LIVING SYSTEMS (159-1) DAVIS, CALIFORNIA SOLAR/1046-79/01
REPORT PERIOD: JANUARY,1979

SITE/SYSTEM DESCRIPTION:
THE LIVING SYSTEMS SOLAR DOMESTIC HOT WATER SYSTEM PROVIDES PREHEAT TO THE BUILDING DOMESTIC HOT WATER SYSTEM . THIS ACTIVE SYSTEM USES FLAT PLATE COLLECTORS (46 SQ.FT.) TO HEAT WATER DIRECTLY IN A 82 GALLON STORAGE TANK. AUXILIARY HOT WATER ENERGY IS PROVIDED BY NATURAL GAS IN THE 20 GALLON HOT WATER HEATER.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	1.236	GIGA JOULES
	289136	KJ/SQ.M.
COLLECTED SOLAR ENERGY	0.000	GIGA JOULES
	0	KJ/SQ.M.
AVERAGE AMBIENT TEMPERATURE	7	DEGREES C
AVERAGE BUILDING TEMPERATURE	17	DEGREES C
ECSS SOLAR CONVERSION EFFICIENCY	0.07	
ECSS OPERATING ENERGY	0.000	GIGA JOULES
TOTAL SYSTEM OPERATING ENERGY	0.000	GIGA JOULES
TOTAL ENERGY CONSUMED	3.151	GIGA JOULES

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	1.934	N.A.	N.A.	1.934 GIGA JOULES
SOLAR FRACTION	13	N.A.	N.A.	13 PERCENT
SOLAR ENERGY USED	0.082	N.A.	N.A.	0.082 GIGA JOULES
OPERATING ENERGY	N.A.	N.A.	N.A.	0.000 GIGA JOULES
AUX. THERMAL ENG	1.885	N.A.	N.A.	1.885 GIGA JOULES
AUX. ELECTRIC FUEL	N.A.	N.A.	N.A.	N.A. GIGA JOULES
AUX. FOSSIL FUEL	3.141	N.A.	N.A.	3.141 GIGA JOULES
ELECTRICAL SAVINGS	N.A.	N.A.	N.A.	0.000 GIGA JOULES
FOSSIL SAVINGS	0.137	N.A.	N.A.	0.137 GIGA JOULES

SYSTEM PERFORMANCE FACTOR: 0.616

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978, SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENERGY COLLECTION AND STORAGE SUBSYSTEM (ECSS)

SITE: LIVING SYSTEMS (159-1) DAVIS, CALIFORNIA SOLAR/1046-79/01
REPORT PERIOD: JANUARY,1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	AMBIENT TEMP DEG-F	ENERGY TO LOADS MILLION BTU	AUX THERMAL TO ECSS MILLION BTU	ECSS OPERATING ENERGY MILLION BTU	ECSS ENERGY REJECTED MILLION BTU	ECSS SOLAR CONVERSION EFFICIENCY
1	0.056	34	0.001	N	0.000	N	0.016
2	0.006	37	0.002	O	0.000	O	0.323
3	0.018	41	0.006	T	0.000	T	0.316
4	0.048	46	0.003		0.000		0.063
5	0.004	47	0.004	A	0.000	A	1.170
6	0.029	44	0.001	P	0.000	P	0.049
7	0.000	45	0.001	P	0.000	P	0.000
8	0.001	48	0.002	L	0.000	L	2.136
9	0.005	50	0.002	I	0.000	I	0.427
10	0.003	50	0.002	C	0.000	C	0.534
11	0.003	54	0.001	A	0.000	A	0.415
12	0.064	52	0.002	B	0.000	B	0.026
13	0.008	44	0.008	L	0.000	L	0.961
14	0.012	47	0.003	E	0.000	E	0.276
15	0.007	47	0.002		0.000		0.275
16	0.079	45	0.002		0.000		0.023
17	0.055	43	0.005		0.000		0.094
18	0.055	46	0.003		0.000		0.058
19	0.074	43	0.001		0.000		0.015
20	0.039	42	0.002		0.000		0.055
21	0.064	46	0.001		0.000		0.022
22	0.073	44	0.002		0.000		0.032
23	0.034	44	0.002		0.000		0.053
24	0.005	43	0.002		0.000		0.489
25	0.084	41	0.003		0.000		0.040
26	0.087	42	0.003		0.000		0.037
27	0.079	41	0.002		0.000		0.022
28	0.087	41	0.001		0.000		0.015
29	0.081	38	0.001		0.000		0.018
30	0.005	39	0.003		0.000		0.693
31	0.008	38	0.002		0.000		0.201
SUM	1.171	-	0.078	N.A.	0.000	N.A.	-
AVG	0.038	44	0.003	N.A.	0.000	N.A.	0.066
NBS ID	Q001	N113			Q102		N111

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
COLLECTOR ARRAY PERFORMANCE

SITE: LIVING SYSTEMS (159-1) DAVIS, CALIFORNIA SOLAR/1046-79/01
REPORT PERIOD: JANUARY,1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	OPERATIONAL INCIDENT ENERGY MILLION BTU	COLLECTED SOLAR ENERGY MILLION BTU	DAYTIME AMBIENT TEMP DEG F	COLLECTOR ARRAY EFFICIENCY
1	0.056	0.000	0.000	43	0.000
2	0.006	0.000	0.000	43	0.000
3	0.018	0.000	0.000	46	0.000
4	0.048	0.000	0.000	51	0.000
5	0.004	0.000	0.000	52	0.000
6	0.029	0.000	0.000	51	0.000
7	0.000	0.000	0.000	46	0.000
8	0.001	0.000	0.000	50	0.000
9	0.005	0.000	0.000	52	0.000
10	0.003	0.000	0.000	51	0.000
11	0.003	0.000	0.000	57	0.000
12	0.064	0.000	0.000	61	0.000
13	0.008	0.000	0.000	47	0.000
14	0.012	0.000	0.000	48	0.000
15	0.007	0.000	0.000	49	0.000
16	0.079	0.000	0.000	53	0.000
17	0.055	0.000	0.000	50	0.000
18	0.055	0.000	0.000	52	0.000
19	0.074	0.000	0.000	51	0.000
20	0.039	0.000	0.000	49	0.000
21	0.064	0.000	0.000	56	0.000
22	0.073	0.000	0.000	53	0.000
23	0.034	0.000	0.000	48	0.000
24	0.005	0.000	0.000	45	0.000
25	0.084	0.000	0.000	49	0.000
26	0.087	0.000	0.000	51	0.000
27	0.079	0.000	0.000	50	0.000
28	0.087	0.000	0.000	49	0.000
29	0.081	0.000	0.000	47	0.000
30	0.005	0.000	0.000	43	0.000
31	0.008	0.000	0.000	42	0.000
SUM	1.171	0.000	0.000	-	-
AVG	0.038	0.000	0.000	49	0.000
NBSID	Q001		Q100		N100

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
STORAGE PERFORMANCE

SITE: LIVING SYSTEMS (159-1) DAVIS, CALIFORNIA SOLAR/1046-79/01
REPORT PERIOD: JANUARY,1979

DAY OF MONTH	ENERGY TO STORAGE MILLION BTU	ENERGY FROM STORAGE MILLION BTU	CHANGE IN STORED ENERGY MILLION BTU	STORAGE AVERAGE TEMP DEG F	STORAGE EFFICIENCY
1	0.000	0.001	N	N	N
2	0.000	0.001	O	O	O
3	0.000	-0.003	T	T	T
4	0.000	0.002			
5	0.000	-0.001	A	A	A
6	0.000	0.001	P	P	P
7	0.000	0.000	P	P	P
8	0.000	0.001	L	L	L
9	0.000	0.001	I	I	I
10	0.000	0.001	C	C	C
11	0.000	0.001	A	A	A
12	0.000	0.001	B	B	B
13	0.000	0.000	L	L	L
14	0.000	0.002	E	E	E
15	0.000	0.001			
16	0.000	-0.001			
17	0.000	0.001			
18	0.000	0.002			
19	0.000	0.001			
20	0.000	0.002			
21	0.000	0.001			
22	0.000	0.002			
23	0.000	0.002			
24	0.000	0.003			
25	0.000	0.002			
26	0.000	0.003			
27	0.000	0.002			
28	0.000	0.001			
29	0.000	0.002			
30	0.000	0.002			
31	0.000	0.002			
SUM	0.000	0.037	N.A.	-	-
AVG	0.000	0.001	N.A.	N.A.	N.A.
NBS ID	Q200	Q201	Q202		N108

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
HOT WATER SUBSYSTEM

SITE: LIVING SYSTEMS (159-1) DAVIS, CALIFORNIA SOLAR/1046-79/01
REPORT PERIOD: JANUARY,1979

DAY OF MON.	HOT WATER LOAD MILLION BTU	SOLAR FR.OF LOAD PER CENT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	SUP. WAT. TEMP DEG F	HOT WAT. TEMP DEG F	HOT WATER USED GAL
1	0.012	8	0.001	N	0.020	N	0.033	N	0.002	61	114	32
2	0.100	4	0.002	O	0.087	O	0.145	O	0.003	60	119	210
3	0.122	35	0.006	T	0.063	T	0.106	T	0.009	63	125	245
4	0.084	26	0.003		0.063		0.106		0.005	60	121	174
5	0.044	43	0.004	A	0.018	A	0.029	A	0.007	65	119	112
6	0.032	3	0.001	P	0.054	P	0.090	P	0.002	60	127	58
7	0.012	9	0.001	P	0.015	P	0.024	P	0.001	60	126	21
8	0.062	11	0.002	L	0.075	L	0.125	L	0.004	61	116	135
9	0.048	6	0.002	I	0.066	I	0.110	I	0.003	60	111	106
10	0.045	12	0.002	C	0.055	C	0.092	C	0.003	61	117	100
11	0.029	5	0.001	A	0.039	A	0.065	A	0.002	61	119	67
12	0.052	5	0.002	B	0.057	B	0.096	B	0.003	62	124	102
13	0.095	31	0.008	L	0.069	L	0.114	L	0.014	65	125	199
14	0.078	25	0.003	E	0.072	E	0.120	E	0.005	63	128	148
15	0.055	8	0.002		0.060		0.101		0.003	62	115	112
16	0.048	32	0.002		0.024		0.040		0.003	63	121	103
17	0.042	12	0.005		0.083		0.138		0.009	68	116	100
18	0.051	8	0.003		0.052		0.086		0.005	63	126	104
19	0.027	10	0.001		0.035		0.059		0.002	61	120	58
20	0.059	5	0.002		0.060		0.100		0.004	62	123	117
21	0.040	5	0.001		0.047		0.078		0.002	63	126	76
22	0.066	5	0.002		0.069		0.114		0.004	61	123	126
23	0.054	4	0.002		0.062		0.104		0.003	61	120	129
24	0.061	4	0.002		0.075		0.125		0.004	60	115	143
25	0.065	10	0.003		0.057		0.096		0.006	60	121	116
26	0.107	11	0.003		0.060		0.101		0.005	61	126	226
27	0.091	4	0.002		0.088		0.147		0.003	61	116	188
28	0.083	7	0.001		0.082		0.137		0.002	63	126	192
29	0.035	14	0.001		0.042		0.069		0.002	61	117	78
30	0.085	8	0.003		0.082		0.136		0.006	61	117	172
31	0.046	4	0.002		0.055		0.092		0.003	60	114	95
SUM	1.834	-	0.078	N.A.	1.787	N.A.	2.978	N.A.	0.129	-	-	3842
AVG	0.059	13	0.003	N.A.	0.058	N.A.	0.096	N.A.	0.004	62	120	124
NBS	Q302	N300	Q300	Q303	Q301	Q305	Q306	Q311	Q313	N305	N307	N308

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENVIRONMENTAL SUMMARY

SITE: LIVING SYSTEMS (159-1) DAVIS, CALIFORNIA SOLAR/1046-79/01
REPORT PERIOD: JANUARY,1979

DAY OF MONTH	TOTAL INSOLATION BTU/SQ.FT	DIFFUSE INSOLATION BTU/SQ.FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIRECTION DEGREES	WIND SPEED M.P.H.
1	1209	N	34	43	83	*	2
2	141	C	37	43	74	*	4
3	383	T	41	46	74	*	2
4	1043		46	51	87	*	10
5	82	A	47	52	94	*	3
6	638	P	44	51	90	*	1
7	0	P	45	46	99	*	1
8	24	L	48	50	100	*	6
9	100	I	50	52	100	*	3
10	63	C	50	51	100	*	8
11	68	A	54	57	100	*	15
12	1385	B	52	61	82	*	7
13	183	L	44	47	97	*	3
14	256	E	47	48	98	*	15
15	150		47	49	100	*	11
16	1716		45	53	88	*	6
17	1201		43	50	92	*	6
18	1186		46	52	90	*	2
19	1605		43	51	87	77	2
20	849		42	49	93	0	1
21	1392		46	56	88	0	1
22	1581		44	53	83	196	3
23	733		44	48	94	19	4
24	108		43	45	92	80	2
25	1827		41	49	67	213	13
26	1889		42	51	46	217	11
27	1720		41	50	64	*	5
28	1884		41	49	50	212	13
29	1755		38	47	51	*	3
30	107		39	43	76	*	7
31	183		38	42	96	213	6
SUM	25461	N.A.	-	-	-	-	-
AVG	821	N.A.	44	49	85	*	6
NBS ID	Q001		N113			N115	N114

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: LIVING SYSTEMS (159-2) DAVIS, CALIFORNIA SOLAR/1046-79/01
REPORT PERIOD: JANUARY,1979

SITE/SYSTEM DESCRIPTION:
THE LIVING SYSTEMS PASSIVE SOLAR SPACE HEATING SYSTEM PROVIDES SPACE HEATING FOR A 1700 SQUARE FOOT SINGLE FAMILY DWELLING. THE LARGE SOUTH-FACING WINDOW WALL AND CLERESTORY SKYLIGHT PERMIT DIRECT WINTER SUN TO ENTER THE HOUSE. SOLAR ENERGY THERMAL STORAGE IS PROVIDED BY BOTH WATER FILLED TUBES AND THE CONCRETE SLAB FLOOR. MOVABLE SHUTTERS AND INSULATING CURTAINS PROVIDE CAPABILITY TO REDUCE NIGHT HEAT LOSSES. SUMMER OVERHEAT PROTECTION IS PROVIDED BY ROOF OVERHANGS AND BY NATURAL VENTILATION. AUXILIARY SPACE HEAT IS PROVIDED BY A NATURAL GAS FURNACE.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	7.123	MILLION BTU
	26091	BTU/SQ.FT.
COLLECTED SOLAR ENERGY	4.800	MILLION BTU
	17580	BTU/SQ.FT.
AVERAGE AMBIENT TEMPERATURE	44	DEGREES F
AVERAGE BUILDING TEMPERATURE	63	DEGREES F
ECSS SOLAR CONVERSION EFFICIENCY	0.70	
ECSS OPERATING ENERGY	N.A.	MILLION BTU
TOTAL SYSTEM OPERATING ENERGY	N.A.	MILLION BTU
TOTAL ENERGY CONSUMED	7.096	MILLION BTU

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL	
LOAD	N.A.	5.866	N.A.	5.866	MILLION BTU
SOLAR FRACTION	N.A.	85	N.A.	85	PERCENT
SOLAR ENERGY USED	N.A.	4.996	N.A.	4.996	MILLION BTU
OPERATING ENERGY	N.A.	N.A.	N.A.	N.A.	MILLION BTU
AUX. THERMAL ENERGY	N.A.	0.869	N.A.	0.869	MILLION BTU
AUX. ELECTRIC FUEL	N.A.	N.A.	N.A.	N.A.	MILLION BTU
AUX. FOSSIL FUEL	N.A.	2.098	N.A.	2.098	MILLION BTU
ELECTRICAL SAVINGS	N.A.	N.A.	N.A.	N.A.	MILLION BTU
FOSSIL SAVINGS	N.A.	8.327	N.A.	8.327	MILLION BTU

SYSTEM PERFORMANCE FACTOR: 2.796

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978, SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: LIVING SYSTEMS (159-2) DAVIS, CALIFORNIA SOLAR/1046-79/01
REPORT PERIOD: JANUARY,1979

SITE/SYSTEM DESCRIPTION:
THE LIVING SYSTEMS PASSIVE SOLAR SPACE HEATING SYSTEM PROVIDES SPACE HEATING FOR A 1700 SQUARE FOOT SINGLE FAMILY DWELLING. THE LARGE SOUTH-FACING WINDOW WALL AND CLERESTORY SKYLIGHT PERMIT DIRECT WINTER SUN TO ENTER THE HOUSE. SOLAR ENERGY THERMAL STORAGE IS PROVIDED BY BOTH WATER FILLED TUBES AND THE CONCRETE SLAB FLOOR. MOVABLE SHUTTERS AND INSULATING CURTAINS PROVIDE CAPABILITY TO REDUCE NIGHT HEAT LOSSES. SUMMER OVERHEAT PROTECTION IS PROVIDED BY ROOF OVERHANGS AND BY NATURAL VENTILATION. AUXILIARY SPACE HEAT IS PROVIDED BY A NATURAL GAS FURNACE.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	7.515 GIGA JOULES
	296289 KJ/SQ.M.
COLLECTED SOLAR ENERGY	5.064 GIGA JOULES
	199643 KJ/SQ.M.
AVERAGE AMBIENT TEMPERATURE	7 DEGREES C
AVERAGE BUILDING TEMPERATURE	17 DEGREES C
ECSS SOLAR CONVERSION EFFICIENCY	0.70
ECSS OPERATING ENERGY	N.A. GIGA JOULES
TOTAL SYSTEM OPERATING ENERGY	N.A. GIGA JOULES
TOTAL ENERGY CONSUMED	7.486 GIGA JOULES

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	N.A.	6.189	N.A.	6.189 GIGA JOULES
SOLAR FRACTION	N.A.	85	N.A.	85 PERCENT
SOLAR ENERGY USED	N.A.	5.271	N.A.	5.271 GIGA JOULES
OPERATING ENERGY	N.A.	N.A.	N.A.	N.A. GIGA JOULES
AUX. THERMAL ENG	N.A.	0.917	N.A.	0.917 GIGA JOULES
AUX. ELECTRIC FUEL	N.A.	N.A.	N.A.	N.A. GIGA JOULES
AUX. FOSSIL FUEL	N.A.	2.213	N.A.	2.213 GIGA JOULES
ELECTRICAL SAVINGS	N.A.	N.A.	N.A.	N.A. GIGA JOULES
FOSSIL SAVINGS	N.A.	8.784	N.A.	8.784 GIGA JOULES

SYSTEM PERFORMANCE FACTOR: 2.796

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978, SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
COLLECTOR ARRAY PERFORMANCE

SITE: LIVING SYSTEMS (159-2) DAVIS, CALIFORNIA SOLAR/1046-79/01
REPORT PERIOD: JANUARY,1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	OPERATIONAL INCIDENT ENERGY MILLION BTU	COLLECTED SOLAR ENERGY MILLION BTU	DAYTIME AMBIENT TEMP DEG F	COLLECTOR ARRAY EFFICIENCY
1	0.345	0.113	N	43	N
2	0.030	0.014	O	43	O
3	0.102	0.081	T	46	T
4	0.293	0.224		51	
5	0.019	0.013	A	52	A
6	0.178	0.068	P	51	P
7	0.000	0.000	P	46	P
8	0.007	0.004	L	50	L
9	0.021	0.012	I	52	I
10	0.014	0.004	C	51	C
11	0.014	0.000	A	57	A
12	0.397	0.385	B	61	B
13	0.046	0.016	L	47	L
14	0.063	0.046	E	48	E
15	0.037	0.004		49	
16	0.487	0.478		53	
17	0.342	0.309		50	
18	0.337	0.177		52	
19	0.449	0.443		51	
20	0.234	0.213		49	
21	0.391	0.295		56	
22	0.455	0.408		53	
23	0.200	0.100		48	
24	0.029	0.003		45	
25	0.521	0.517		49	
26	0.534	0.357		51	
27	0.483	0.189		50	
28	0.527	0.387		49	
29	0.494	0.484		47	
30	0.029	0.029		43	
31	0.043	0.004		42	
SUM	7.123	5.377	4.800	-	-
AVG	0.230	0.173	N.A.	49	N.A.
NBSID	Q001		Q100		N100

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SPACE HEATING SUBSYSTEM

SITE: LIVING SYSTEMS (159-2) DAVIS, CALIFORNIA SOLAR/1046-79/01
REPORT PERIOD: JANUARY,1979

DAY OF MON.	SPACE HEATING LOAD MILLION BTU	SOLAR FR.OF LOAD PCT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	BLDG TEMP DEG. F	AMB TEMP DEG. F
1	0.300	69	0.208	N	0.092	N	0.192	N	0.347	63	34
2	0.274	54	0.148	C	0.127	O	0.250	O	0.246	61	37
3	0.242	35	0.084	T	0.158	T	0.309	T	0.141	62	41
4	0.251	66	0.164		0.086		0.176		0.274	64	46
5	0.164	34	0.056	A	0.108	A	0.218	A	0.093	64	47
6	0.154	99	0.152	P	0.002	P	0.017	P	0.254	63	44
7	0.137	81	0.111	P	0.026	P	0.060	P	0.186	59	45
8	0.081	63	0.051	L	0.030	L	0.068	L	0.085	62	48
9	-0.014	132	-0.019	I	0.005	I	0.022	I	-0.032	64	50
10	0.020	85	0.017	C	0.003	C	0.019	C	0.028	66	50
11	0.063	97	0.061	A	0.002	A	0.022	A	0.101	65	54
12	0.001	-36	-0.000	B	0.002	B	0.020	B	-0.001	67	52
13	0.152	98	0.148	L	0.004	L	0.022	L	0.247	64	44
14	0.165	98	0.161	E	0.004	E	0.020	E	0.269	64	47
15	0.164	79	0.130		0.034		0.082		0.217	63	47
16	0.214	86	0.185		0.029		0.066		0.309	63	45
17	0.177	96	0.171		0.007		0.022		0.284	65	43
18	0.159	100	0.159		0.000		0.017		0.265	66	46
19	0.253	100	0.253		0.000		0.015		0.422	66	43
20	0.244	99	0.242		0.003		0.015		0.403	65	42
21	0.176	99	0.174		0.002		0.018		0.291	64	46
22	0.263	87	0.228		0.035		0.077		0.380	65	44
23	0.189	94	0.178		0.011		0.035		0.297	64	44
24	0.176	81	0.143		0.033		0.077		0.239	62	43
25	0.279	90	0.251		0.028		0.069		0.419	62	41
26	0.277	99	0.276		0.002		0.022		0.460	62	42
27	0.264	99	0.262		0.002		0.022		0.437	63	41
28	0.322	100	0.322		0.000		0.022		0.537	63	41
29	0.313	92	0.286		0.025		0.066		0.477	62	38
30	0.194	93	0.181		0.013		0.041		0.301	61	39
31	0.211	100	0.211		0.000		0.019		0.351	60	38
SUM	5.866	-	4.996	N.A.	0.869	N.A.	2.098	N.A.	8.327	-	-
AVG	0.189	85	0.161	N.A.	0.028	N.A.	0.068	N.A.	0.269	63	44
NBS	Q402	N400	Q400	Q403	Q401		Q410	Q415	Q417	N406	N113

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENVIRONMENTAL SUMMARY

SITE: LIVING SYSTEMS (159-2) DAVIS, CALIFORNIA SOLAR/1046-79/01
REPORT PERIOD: JANUARY,1979

DAY OF MONTH	TOTAL INSOLATION BTU/SQ.FT	DIFFUSE INSOLATION BTU/SQ.FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIRECTION DEGREES	WIND SPEED M.P.H.
1	1262	N	34	43	83	*	2
2	111	C	37	43	74	*	4
3	375	T	41	46	74	*	2
4	1072		46	51	87	*	10
5	69	A	47	52	94	*	3
6	651	P	44	51	90	*	1
7	0	P	45	46	99	*	1
8	26	L	48	50	100	*	6
9	77	I	50	52	100	*	3
10	51	C	50	51	100	*	8
11	53	A	54	57	100	*	15
12	1454	B	52	61	82	*	7
13	170	L	44	47	97	*	3
14	232	E	47	48	98	*	15
15	135		47	49	100	*	11
16	1785		45	53	88	*	6
17	1252		43	50	92	*	6
18	1234		46	52	90	*	2
19	1646		43	51	87	77	2
20	857		42	49	93	0	1
21	1434		46	56	88	0	1
22	1668		44	53	83	196	3
23	734		44	48	94	19	4
24	106		43	45	92	80	2
25	1909		41	49	67	213	13
26	1956		42	51	46	217	11
27	1769		41	50	64	*	5
28	1930		41	49	50	212	13
29	1809		38	47	51	*	3
30	106		39	43	76	*	7
31	156		38	42	96	213	6
SUM	26091	N.A.	-	-	-	-	-
AVG	842	N.A.	44	49	85	*	6
NBS ID	Q001		N113			N115	N114

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
PASSIVE SPACE HEATING

SITE: LIVING SYSTEMS (159-2) DAVIS, CALIFORNIA SOLAR/1046-79/01
REPORT PERIOD: JANUARY,1979

DAY OF MON	SPACE HEATING LOAD MILLION BTU	SOLAR ENERGY USED MILLION BTU	CHANGE IN STORE ENERGY MILLION BTU	AVERAGE STORAGE TEMP DEG F	DIRECT SOLAR UTIL EFFIC	AUX THERMAL USED MILLION BTU	BLDG TEMP DEG F	AMB TEMP DEG F	WIND AVG SPEED MPH	WIND AVG DIR DEG	SOLAR FR LOAD PER CENT
1	0.300	0.208	-0.028	69.2	0.604	0.092	63	34	1.7	*	69
2	0.274	0.147	-0.114	67.3	4.866	0.127	61	37	3.7	*	54
3	0.241	0.084	0.028	66.3	0.824	0.157	62	41	1.9	*	35
4	0.250	0.164	0.052	67.6	0.561	0.086	64	46	10.2	*	66
5	0.163	0.055	-0.016	67.4	2.978	0.108	64	47	3.5	*	34
6	0.154	0.152	-0.060	67.6	0.858	0.001	63	44	1.1	*	99
7	0.137	0.111	-0.121	65.7	0.000	0.025	59	45	1.2	*	81
8	0.081	0.051	0.047	65.6	7.221	0.029	62	48	6.1	*	63
9	-0.014	-0.018	0.116	67.3	-0.901	0.004	64	50	3.2	*	132
10	0.020	0.016	0.041	69.0	1.211	0.003	66	50	8.2	*	85
11	0.062	0.060	-0.066	69.1	4.234	0.002	65	54	15.3	*	97
12	0.001	0.000	0.218	70.7	-0.001	0.001	67	52	6.7	*	-36
13	0.151	0.148	-0.126	70.2	3.195	0.003	64	44	3.1	*	98
14	0.164	0.161	-0.074	68.6	2.544	0.003	64	47	15.0	*	98
15	0.164	0.130	-0.068	67.9	3.531	0.034	63	47	11.4	*	79
16	0.214	0.185	0.120	68.1	0.380	0.028	63	45	6.4	*	86
17	0.177	0.170	0.086	70.9	0.499	0.006	65	43	6.3	*	96
18	0.158	0.158	0.001	71.5	0.472	0.000	66	46	2.1	*	100
19	0.253	0.253	0.091	72.1	0.564	0.000	66	43	2.1	77	100
20	0.244	0.241	-0.084	71.7	1.033	0.002	65	42	0.8	0	99
21	0.176	0.174	-0.026	70.1	0.446	0.002	64	46	0.9	0	99
22	0.263	0.228	0.057	70.4	0.501	0.035	65	44	3.5	196	87
23	0.188	0.177	-0.080	69.4	0.888	0.010	64	44	3.7	19	94
24	0.175	0.143	-0.105	68.0	4.956	0.032	62	43	2.2	80	81
25	0.279	0.251	0.034	68.8	0.482	0.027	62	41	12.6	213	90
26	0.277	0.275	0.111	70.5	0.517	0.001	62	42	10.6	217	99
27	0.263	0.262	-0.017	70.5	0.543	0.001	63	41	4.7	*	99
28	0.322	0.322	-0.068	70.2	0.612	0.000	63	41	13.3	212	100
29	0.312	0.286	0.012	69.6	0.579	0.025	62	38	3.5	*	92
30	0.193	0.180	-0.024	68.5	6.243	0.013	61	39	6.9	*	93
31	0.210	0.210	-0.135	68.0	4.947	0.000	60	38	5.9	213	100
SUM	5.865	4.995	-0.196	-	-	0.869	-	-	-	-	-
AVG	0.189	0.161	-0.006	69.0	0.701	0.028	63	44	5.7	*	85
NBS	Q402	Q400	Q202			Q401	N405	N113	N114	N115	N400

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
PASSIVE SYSTEM ENVIRONMENT

SITE: LIVING SYSTEMS (159-2) DAVIS, CALIFORNIA SOLAR/1046-79/01
REPORT PERIOD: JANUARY,1979

DAY OF MON	BUILDING COMFORT ZONE 1	BLDG COMF ZONE 2	BUILDING TEMP MIDNIGHT DEG F	BUILDING TEMP 6 AM DEG F	BUILDING TEMP NOON DEG F	BUILDING TEMP 6 PM DEG F	INTERIOR RELATIVE HUMIDITY PERCENT	AMB TEMP DEG F	DAYTIME AMB TEMP DEG F	INCIDENT SOLAR ENERGY MILLION BTU	AVG STOR TEMP DEG F
1	69	66	63	60	62	64	31	34	43	0.345	69
2	66	65	61	60	62	61	31	37	43	0.030	67
3	66	65	65	59	63	64	33	41	46	0.102	66
4	68	67	65	61	68	65	35	46	51	0.293	68
5	67	67	64	62	66	64	39	47	52	0.019	67
6	67	66	60	62	64	63	37	44	51	0.178	68
7	65	62	62	58	58	58	38	45	46	0.000	66
8	66	64	64	61	62	61	42	48	50	0.007	66
9	68	65	67	64	63	64	43	50	52	0.021	67
10	70	66	68	65	66	65	43	50	51	0.014	69
11	69	66	65	65	65	64	47	54	57	0.014	69
12	72	68	65	65	71	70	41	52	61	0.397	71
13	70	67	65	64	64	64	40	44	47	0.046	70
14	68	66	63	63	65	64	41	47	48	0.053	69
15	67	65	61	63	63	63	42	47	49	0.037	68
16	68	65	65	59	67	65	40	45	53	0.487	68
17	72	67	66	63	67	65	35	43	50	0.342	71
18	72	68	65	64	67	67	37	46	52	0.337	72
19	73	68	66	63	69	69	36	43	51	0.449	72
20	71	68	63	63	66	66	37	42	49	0.234	72
21	70	67	64	62	67	66	37	46	56	0.391	70
22	70	68	64	61	67	68	35	44	53	0.455	70
23	68	67	64	62	63	65	37	44	48	0.200	69
24	67	66	63	62	62	63	37	43	45	0.029	68
25	69	65	60	59	64	62	29	41	49	0.521	69
26	71	65	64	58	65	66	24	42	51	0.534	70
27	70	66	65	60	63	66	27	41	50	0.483	70
28	70	66	61	62	63	64	26	41	49	0.527	70
29	69	65	62	57	63	64	25	38	47	0.494	70
30	68	65	62	60	61	62	28	39	43	0.029	68
31	67	63	61	60	60	60	31	38	42	0.043	68
SUM	-	-	-	-	-	-	-	-	-	7.123	-
AVG	69	66	64	62	64	64	36	44	49	0.230	69
NBS								N113			

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

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